**Geoscientific
Model Development
Discussions**

Interactive comment on "Design and implementation of the infrastructure of HadGEM3: the next-generation Met Office climate modelling system" *by* H. T. Hewitt et al.

Anonymous Referee #2

Received and published: 17 January 2011

This paper presents well written and very useful documentation of the HadGEM3. The manuscript would be improved by some further detail and clarification, as per my comments below:

1. The MetOffice releases code updates for the UM on a fairly regular basis. These have designation of form UM6.X, UM7.X , etc. It would be helpful if the authors were to note the code updates from which the HadGEM3 revision 1.1 featured here can be configured. Are there any code updates for which it is the default configuration?

2. The Met Office performs standardised assessments on its latest version of the atmospheric and coupled model routinely every 6 months ("March 2009 assessment",

"Sept 2009 assessment", etc.). It would be helpful if the authors were to note the assessment corresponding to the HadGEM3 r1.1 as featured here.

3. Apparent slight inconsistency of the terminology: p4, lines 15-16: "... r1.1 ....is not, in principal, fixed to any particular resolution." P5, lines 29 – p6, l1: "... r1.1 ... has a horizontal resolution of ...." Suggest reword to clarify.

4. p7, line 10: Useful to mention up front here that the T grid for the ocean and sea ice models align (though this is discussed later).

5. p7, line 14: "need for efficient load balancing". Should mention here that this is only for the (vector) platform used at the time. As discussed later, this is not so clear for massively parallel systems now widely used.

6. The use of a B grid for the sea ice and a C grid for the ocean means that the land sea boundaries for the U and V points for the ocean and sea ice will not quite match and so an interpolation is required (p 15). Do any modelling issues arise as a result (e.g., effect on coastal polynyas)?

7. It would be useful to show a schematic clearly illustrating the time-stepping arrangement, with time axis along the page and showing the timing of the ocean, sea ice and atmospheric steps and the coupling times.

8. Suggest explain why CICE was chosen in preference to LIM, the existing NEMO sea ice model, given that the choice introduces the additional complexity of the differing grids (B and C).

9. p 13 line 13: Define λj, Φj.

10. p 13, lines 25-25: Note whether any issues are likely to arise as a result of possible non-conservation of momentum.

11. p 14, line 1: Reword to "same scalar grid".

12. p. 16, lines 3-7: The change in global ocean heat content in Fig. 6a actually

appears to differ quite significantly from the global net ocean surface heat flux. Why is this? This would seem to suggest significant non-conservation issue somewhere in the ocean model. Similarly, in Fig. 6b, why does the change in global ocean freshwater content not exactly match year-by-year the global net ocean surface freshwater flux?

13. Suggest explain why 1980s forcings are used at the same time as 2000s initialisations are used. The radiative forcing 1980s to 2000s is somewhat different.

14. p 18, lines 7-9: "simulates locations of the storm tracks correctly". Reword – much more analysis would need to be done to make this claim.

15. Fig. 10: Do the calculated poleward transports include all components, including diffusive transports?

16. Is there a maximum allowed depth set for the sea ice? If so, then this should be noted.

17. The Appendices feature a detailed comparison between HadGEM1 and HadGEM3 r1.1. This comparison is useful. However, even more useful would be a comparison between HadGEM2 and HadGEM3 r1.1, especially since HadGEM2 forms the immediate predecessor to HadGEM3, is the basis for the Met Office contribution to the IPCC AR5/CMIP5 modelling program, and is well documented in a series of technical reports. The utility of this paper would be improved by inclusion of a comparison between HadGEM2 and HadGEM3 r1.1.

18. p 23, line 18: Claim of "a realistic QBO" would require substantiation. Reword to, e.g., "an improved stratospheric Quasi-biennial Oscillation". Note that QBO needs spelling out.

19. Section A4. There is little said about the land surface scheme. At least note the scheme used (MOSES?).

20. A figure showing the global model orography would be useful. Also, a little mode detail on the steps in the development of the model orography from the original 30" set

would be helpful. Was use of envelope orography (to get the mountain ridges to be of realistic height) considered?

21. p 30, lines 3-5: Presumably this then means that those upper levels of thickness less than 20 m simply were not subject to partial stepping? Also, please specify what is the minimum allowed ocean depth.

22. p 30, line 14: "This is scaled . . ." Do you mean "aht0 was scaled .."?

23, p 30, line 19: What scheme was used to vary the coefficient in the Gent-McWilliams term.

24. p 31: What, if any, bottom boundary layer/downslope flow scheme is used? If none, then was there any special treatment to improve the simulation of the North Atlantic Deep Water formation?

25. p 32, lines 21-24: The treatment of latitudinal resolution in the Sothern Hemisphere ensuring isotropic grid boxes is notable. Is this treatment carried all the way to the Antarctic coast (through $\sim 75°$ S), which would result in a large concentration of rows at such latitudes?

25. p 35, line 13: "albedo being set to 0.61". What was it in HadGEM1?

26. p 35, line 23: "in thickness space." Help the reader by explaining what this means, or reword.

27. p 40, line 3: "allow reproducible restarts". Please explain just what this means. Does this mean that a model simulation can be broken up into segments of arbitrary length and still yield the same identical bit-wise solution? Please clarify whether the HadGEM3 r1.1 actually has this property, which is highly desirable.

28. p 40. line 21: Define "GCOM" more clearly.

29. p41 line 2: "UM was the . . . controlling model component" spell out what this means.

30. p41 lines 15-17: Passage obscure – consider rewording.

31. Fig. 1: Some of the individual heat and freshwater exchanges would be better represented by arrows going both ways up and down.

32. Figs. 4, 5 and 8: Hard to read aspects of these figures in the printout due to small font or arrow size (but ok to read on line).

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